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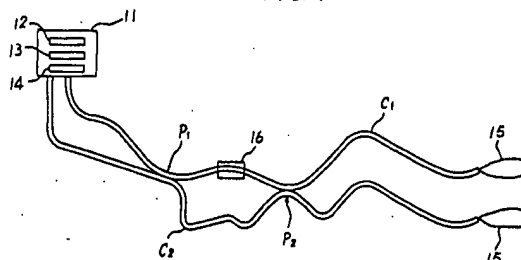
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(54) **METHOD OF IDENTIFYING OPTICAL CABLES.**

(57) A method of identifying optical cables by sending optical signals to optical cables  $C_1$ ,  $C_2$  via transmission means (device 11), applying an external signal via a signal application device (16) to a particular optical cable  $C_1$  that is to be identified, and monitoring a change in the signal by reception detection means (device 11). Harmonic wave signals having a large frequency shift and a large level difference are compared in a relationship between the particular optical cable  $C_1$  to which the external signal is applied and the adjacent optical cable  $C_2$  neighboring to which the external signal is crosstalking. The particular optical cable  $C_1$  is identified without developing any error.

FIG. 1



## BACKGROUND OF THE INVENTION

### [Field of Invention]

This invention relates to a method of identifying a particular optical cable out of a number of similar optical cables on an installation site.

### [Prior Art]

In modern telecommunication systems, optical cables are housed in ducts and conduits and laid along the route of installation.

With the recent development of telecommunication networks, a large number of different optical cables are often laid along a single route of installation to produce a congested condition of cables. Works for branching and/or replacing the installed cables are frequently required.

Fig. 4 of the accompanying drawings schematically illustrates a typical telecommunication network comprising central stations O1, relay stations O2 and terminal stations O3 interconnected by means of a large number of optical cables C, which are often ramified, looped and star-connected.

Since many of these optical cables resemble to one another, skilled workers feel it difficult to single out a particular optical cable that needs to be branched or replaced out of a number of cables that have been laid in a same route of installation.

In an attempt to remedy this problem, Laid-Open Japanese Patent Nos. 2-230105 and 1-230106 propose methods of identifying a particular optical cable by utilizing fluctuation of polarized light in a single mode optical fiber.

Referring to Fig. 5, with these known methods, polarized light is transmitted through a single mode optical fiber of an optical cable C from a light source 1 of a light source station while an external signal (such as mechanical vibration) is applied to the optical cable C at a work site by means of a signal application device 2 so that any fluctuation in the level of polarized light caused by the external signal may be detected to identify the optical fiber by a photodetector 3 as the light is received by a light receiving device 4 at a detecting station.

More specifically, while the operator of the light source station applies a given signal to each optical cable and the operator of the detecting station monitors the reception of the signal, the operator on the work site sequentially applies an external signal to the optical cables laid there on a one by one basis and, each time an external signal is applied to an optical cable, the operator at the work site and his colleague at the detecting station talk over through a radio communication channel, using, for instance, a pair of transceiver sets, to make sure if the optical cable in question is detected or

not.

As the operation of sequentially applying an external signal to the optical cables laid in the work site proceeds on a one by one basis, the operator there will eventually come across the optical cable in question to apply a signal to it and the operator monitoring the signals at the detecting station will detect the cable carrying a fluctuated signal.

Then, the operator at the detecting station notifies his colleague at the work site that the cable to which an external signal is applied last time is the optical cable in question so that the latter can identify the optical cable.

Now, the optical cable is identified and the operator on the work site can proceed to a pre-determined work to be conducted on the cable in question.

Since the above described method of utilizing fluctuation of polarized light involves mechanical vibration which is applied to optical cables as an external signal, the applied external vibration can affect the optical cables laid in the vicinity of the source of vibration to give rise to a phenomenon of cross talk.

In other words, the external signal applied to a particular optical cable can also be given to any of the optical cables laid in the vicinity and produce a condition where identification of cables is impossible or misidentification of cables occurs.

Since the phenomenon of cross talk appears when cables are brought to contact with each other, it may seem that such a phenomenon can be avoided when cables are laid in a manner that eliminates any possibility of mutual contact.

However, laying optical cables under a condition where the possibility of mutual contact is completely eliminated is illogical and irrational from the view point of boosting high density cable installation that has encouraged the development of optical cables.

Besides, in view of the optical cables of existing cable networks that stretch over hundreds of thousands kilometers, it is highly unrealistic to rearrange them under a non-contact condition.

Consequently, it is impossible under the current condition of optical cable installation to totally eliminate the possibility of misidentification of cables when the above described technique of utilizing fluctuation of polarized light is used for identification of particular cables.

## SUMMARY OF THE INVENTION

In view of the above discussed technical problem, it is therefore an object of the present invention to provide a method of identifying a particular optical cable out of a number of similar optical cables on the installation site even when the cables

are under a mutual contact condition.

According to the invention, the above object is achieved by providing a method of identifying a particular optical cable characterized in that it comprises steps of connecting means for transmitting optical signals and means for receiving optical signals to an end or respective opposite ends of a set of optical cables, a signal applying apparatus being provided at an intermediary point of the optical cables along the longitudinal direction, applying sequentially an external signal (mechanical vibration) to the optical cables on one by one basis at the intermediary point thereof along the longitudinal direction by way of said signal applying apparatus when polarized light is transmitted by the means for transmitting optical signals and received by the means for receiving optical signals through the optical cables and identifying a particular optical cable out of the set of optical cables subjected to an external signal by sensing and comparing the output levels of secondary and higher harmonics in the external signals transmitted through the optical cables including said particular cable and those surrounding it in terms of cross talk of the external signal.

It should be noted that higher harmonics of an external signal applied to a particular optical cable hardly gives rise to the phenomenon of cross talk and superposition in the surrounding optical cables.

If any cross talk and superposition of the higher harmonics ever occur in the surrounding optical cables, the harmonics in those surrounding cables undergo an upward shift in the component frequencies.

Thus, by sensing and comparing the output levels of higher harmonics in the external signals transmitted through given optical cables, the particular optical cable to which an external signal is applied can be identified without fail.

In utilizing the method of identifying a particular optical cable out of a number of optical cables according to the invention, both the means for transmitting optical signals and the means for receiving optical signals may be connected to an end of the cables or, alternatively, to respective opposite ends of the cables.

When both the means for transmitting optical signals and the means for receiving optical signals are connected to an end of a set of cables, an additional optical cable which is designed to feed back optical signals is connected to the other end of each cable.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration of the method of identifying a particular optical cable according to the invention.

Fig. 2 is a frequency spectrogram of a signal received by means for receiving optical signals by using the method of the present invention.

Fig. 3 is an illustration obtained by magnifying the level of the higher harmonics of the spectrogram of Fig. 2.

Fig. 4 is a schematic illustration of an optical cable network.

Fig. 5 is a schematic illustration of an optical cable provided with apparatuses to be used for implementing the method of the present invention.

#### BEST MODE OF CARRYING OUT THE INVENTION.

Now, the present invention will be described by referring to the accompanying drawings that illustrate the best mode of carrying out the invention.

Referring firstly to Fig. 1, C1 and C2 respectively denote optical cables, 11 is a transmitter/receiver set for transmitting and receiving optical signals and 15, 15 are optical fibers designed to feed back optical signals while 16 denotes a signal applying apparatus.

Each of the optical cables C1, C2 comprises a large number of optical fibers, including at least a single mode optical fiber to be used for signal transmission and a single mode optical fiber to be used for signal reception, which will be described later.

The optical cables C1, C2 are laid along a single route and housed in a duct or conduit. They are disposed in contact with each other at points P1 and P2.

The transmitter/receiver set 11 comprises a light source 12, a light receiving device 13, a photodetector 14 and other devices and is optically connected to an end of each of the optical cables C1, C2.

More specifically, the light source 12 is connected to the transmission terminal of each of the single mode optical fibers disposed in the optical cables C1, C2 and the photodetector 14 is connected to the reception terminal of each of the single mode optical fibers while the light receiving device 13 and the photodetector 14 are connected with each other.

The optical fibers 15 are also of a single mode type and connected to the respective single mode optical fibers for signal transmission and those for signal reception at the respective other ends of the optical cables C1, C2.

The signal applying apparatus 16 typically comprises a piezoelectric element for generating ultrasonic vibration as mechanical vibration.

Now, assume that the optical cable C1 is the cable to be identified and the signal applying apparatus 16 is fitted to the optical cable C1 at an

intermediary point along the longitudinal direction.

The intermediary point of the optical cable C1 where the signal applying apparatus 16 is fitted is a work site where the optical cable needs to be identified.

Referring to Fig. 1, in an experiment, polarized light was transmitted from the light source 12 of the transmitter/receiver set 11 by way of the single mode optical fibers for signal transmission of the optical cables C1, C2, the optical fibers for signal feedback 15 and the photodetector 14 of the transmitter/receiver set 11 and received by the light receiving device 13, while mechanical vibration (340Hz) was applied to the optical cable C1 as an external signal at an intermediary point along the longitudinal direction in order to identify the optical cable C1.

Fig. 2 shows a frequency spectrogram of the optical output signal of the photodetector 14 obtained in the experiment.

In Fig. 2, S1 denotes the fundamental harmonic of the 340Hz signal applied to the optical cable C1 to be identified, S2 is the higher harmonics of the signal detected in the optical cable C1 and S3 is the fundamental harmonic of the signal detected in the adjacent cable C2.

As clearly seen from Fig. 2, the peak frequencies of the fundamental harmonics S1 and S2 slightly differ from each other, the latter having a peak frequency higher than that of the former by approximately 10Hz.

Fig. 3 shows the higher harmonics of Fig. 2 in an somewhat exaggerated manner.

In Fig. 3, S2 denotes the higher harmonics of the optical cable C1 and S4 denotes those of the optical cable C2.

As is apparent from Fig. 3, since the frequencies of the higher harmonics S4 of the optical cable C2 are higher than the corresponding respective higher harmonics S2 of the optical cable C1 as in the case of the fundamental waves by approximately double of the frequency difference of the fundamental waves or approximately 20Hz.

According to the present invention, the optical cable C1 is identified by comparing the levels of the higher harmonics S2, S4 of the two optical cables C1, C2.

Note that the frequency difference of higher harmonics of a cross talk signal is greater than that of fundamental harmonics of the signal in different optical cables.

Therefore, the particular optical cable C1 can be identified without fault if a narrow bandwidth filter is used to single out the peak level of the higher harmonics S2 and that of the higher harmonics S4.

The transmitter/receiver set 11 to be used for the purpose of the present invention may be alter-

natively replaced by a transmitter set comprising a light source 12 and a receiver set comprising a light receiving device 13 and a photodetector 14, the transmitter set and receiver set being arranged at the opposite ends of a set of optical cables.

With such an arrangement, the operation of identifying a particular optical cable can be carried out by using a single mode optical fiber in each of the optical cables C1, C2 and the optical fibers for signal feedback 15 can be omitted.

The operator at the work site where the signal applying apparatus 16 can communicate with his colleague at the station where the output signal is received through a radio communication channel, using, for instance, a pair of transceiver sets, to make sure if the optical cable in question is detected or not as in the case where a conventional method is utilized.

[Field of Industrial Use]

When the method of the invention of identifying a particular optical cable out of a number of similar optical cables on the installation site by applying an external signal to the optical cables on a one by one basis is used, since the difference in the frequencies and the levels of the higher harmonics generated by the external signal in the particular cable and the surrounding cables that are laid so close to said cable that the phenomenon of cross talk remarkably appears, the optical cable in question can be identified almost without fail.

Therefore, the method of identifying a particular optical cable according to the invention is effective and advantageous when it is used to single out a particular optical cable out of a set of optical cables which are laid close to one another.

## Claims

1. A method of identifying a particular optical cable comprising steps of  
 connecting means for transmitting optical signals and means for receiving optical signals to an end or respective opposite ends of a set of optical cables, a signal applying apparatus being provided at an intermediary point of the optical cables along the longitudinal direction,  
 applying sequentially an external signal (mechanical vibration) to the optical cables on one by one basis at the intermediary point thereof along the longitudinal direction by way of said signal applying apparatus when polarized light is transmitted by the means for transmitting optical signals and received by the means for receiving optical signals through the optical cables and

identifying a particular optical cable out of

the set of optical cables subjected to an external signal by sensing and comparing the output levels of secondary and higher harmonics in the external signals transmitted through the optical cables including said particular cable and those surrounding it in terms of cross talk of the external signal. 5

2. A method of identifying a particular optical cable according to claim 1, wherein a transmitter/receiver set is optically connected to an end of the set of optical cables. 10
3. A method of identifying a particular optical cable according to claim 1, wherein a transmitter set is optically connected to an end of the set of optical cables and a receiving set is connected to the other end of the set of optical cables. 15
4. A method of identifying a particular optical cable according to claim 1, wherein the external signal is mechanical vibration. 20

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FIG. 1

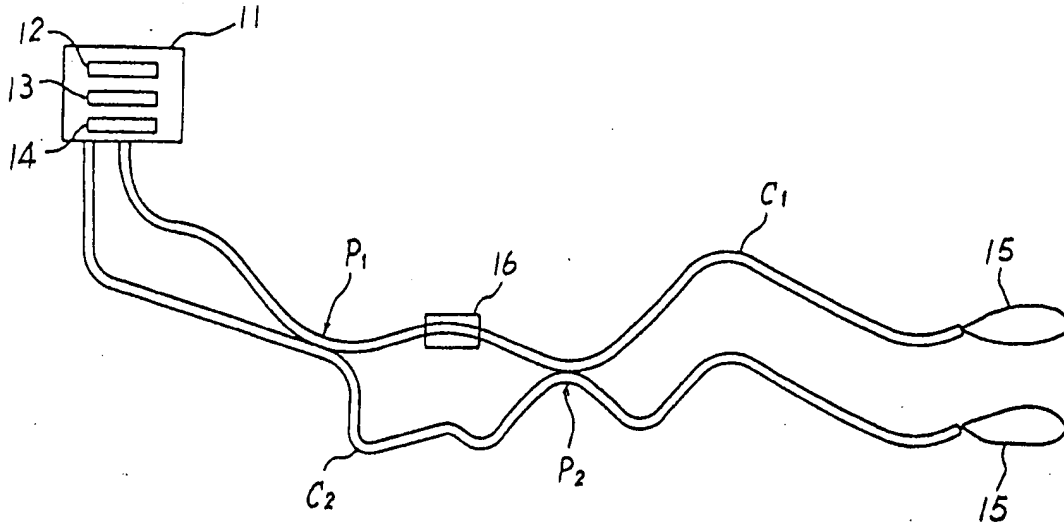


FIG. 2

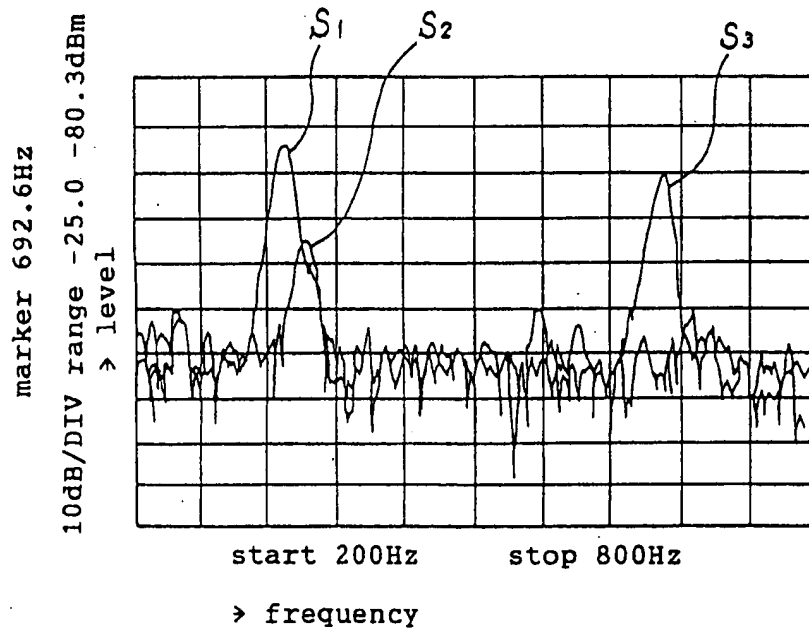


FIG. 3

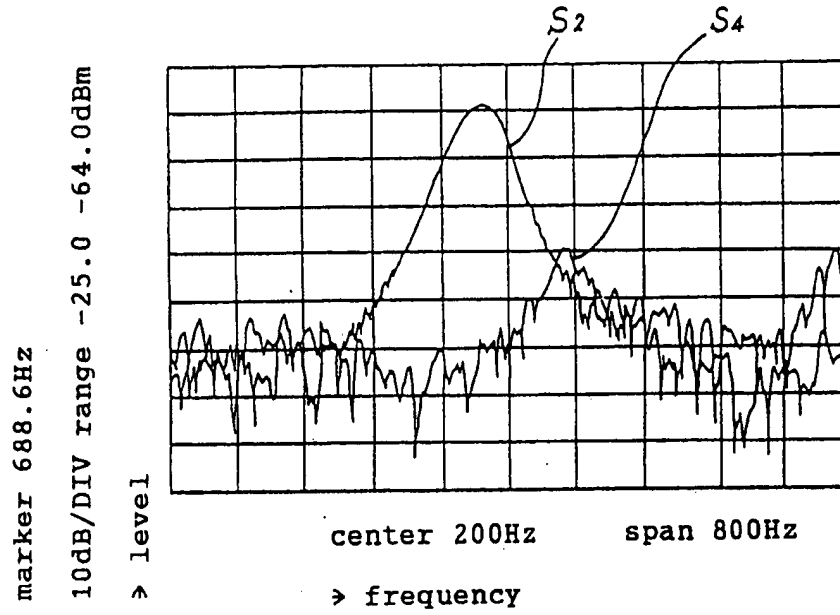


FIG. 4

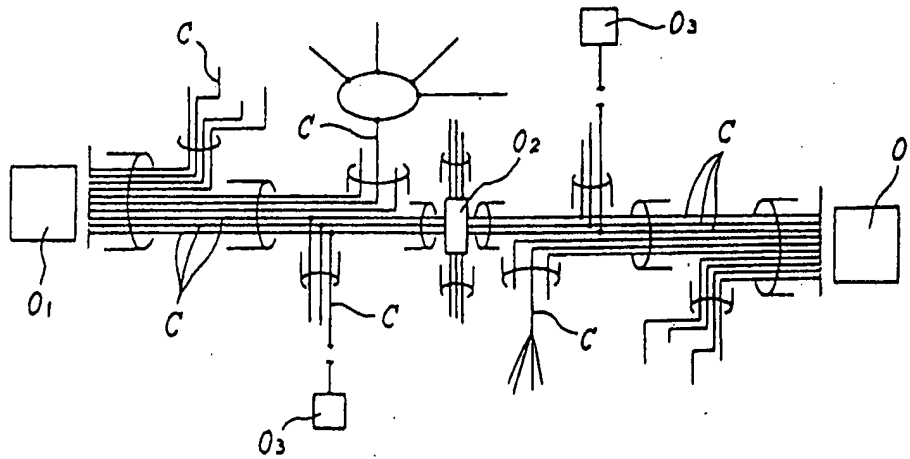
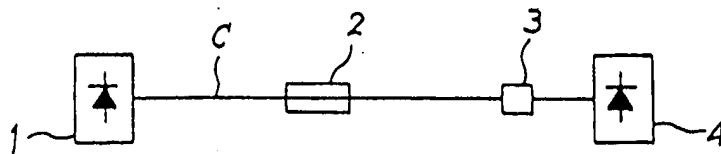


FIG. 5



# INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/01656

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl <sup>5</sup> G01M11/00, G02B6/04		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC	G01M11/00, G02B6/04	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
Jitsuyo Shinan Koho		1970 - 1990
Kokai Jitsuyo Shinan Koho		1971 - 1990
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
A	JP, A, 61-109008 (Ando Denki K.K. and another), May 27, 1986 (27. 05. 86), (Family: none)	1-4
A	JP, A, 63-145939 (Fujikura Ltd.), June 18, 1988 (18. 06. 88), (Family: none)	1-4
A	JP, A, 63-298305 (Nippon Telegraph & Telephone Corp.), December 6, 1988 (06. 12. 88), (Family: none)	1-4
A	JP, A, 1-101504 (Ando Denki K.K. and another), April 19, 1989 (19. 04. 89), (Family: none)	1-4
A	JP, A, 2-230105 (The Furukawa Electric Co., Ltd. and another), September 12, 1990 (12. 09. 90), (Family: none)	1-4
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Z" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
February 20, 1992 (20. 02. 92)		March 10, 1992 (10. 03. 92)
International Searching Authority		Signature of Authorized Officer
Japanese Patent Office		



## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A JP, A, 2-230106 (The Furukawa Electric Co., Ltd. and another),  
September 12, 1990 (12. 09. 90),  
(Family: none)

1-4

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE <sup>1</sup>

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claim numbers because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claim numbers because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING <sup>2</sup>

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

## Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.  
☐ No protest accompanied the payment of additional search fees.